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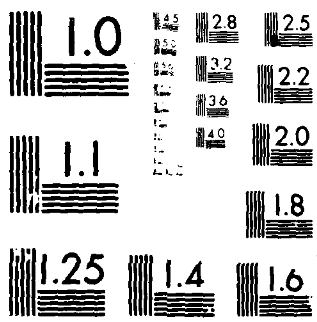
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Intuitive Frequency Judgments as a Function of Prior Expectations, Observed Evidence, and Individual Processing Strategies

Todd E. Marques and William C. Howell

Rice University

Technical Report #79-06

December 1979

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Four experiments were carried out to answer a series of questions on how people formulate impressions of frequency for realistic, repetitive events. In all four studies, the basic paradigm consisted of generating (or reinforcing) prior beliefs regarding the causation of event streams, presenting evidence inconsistent with those prior beliefs imbedded within a "primary" judgment task, and measuring the perceived frequency of the observed evidence. The principal questions were (1) whether the prior expectations determine how

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much attentive effort a subject invests in processing frequentistic evidence, (2) whether demand characteristics of the task influence this allocation of attention, and (3) whether individuals differ reliably in their strategies for processing frequentistic data. The "realistic" task scenario (primary task) was one of evaluating hypothetical college applicants whose credentials included the usual array of personal and academic data. The frequentistic events were applicants of a particular, easily recognized, and culturally salient type (e.g., women; minority groups). "Prior expectations" were created by reinforcing the actual base rates (which were well known to most of the subjects) with additional instruction and/or consistent preconditioning data. Subsequent evidence was discrepant (uaually by 15-20%) from this prior rate. While the findings did not answer all three questions conclusively, they suggested that: (1) prior expectations do play a significant role in subsequent estimates of observed event frequencies; (2) the effect can be ameliorated by task conditions or instructions designed to shift attention to the evidence, but much less easily than might be expected; and (3) the tendency to process (or depth of processing) frequentistic evidence is subject to a strong individual difference component. All these findings are consistent with an attention-control account of intuitive frequency records.

Abstract

Four experiments were carried out to answer a series of questions on how people formulate impressions of frequency for realistic, repetitive events. In all four studies, the basic paradigm consisted of generating (or reinforcing) prior beliefs regarding the causation of event streams, presenting evidence inconsistent with those prior beliefs imbedded within a "primary" judgment task, and measuring the perceived frequency of the observed evidence. The principal questions were (1) whether the prior expectations determine how much attentive effort a subject invests in processing frequentistic evidence, (2) whether demand characteristics of the task influence this allocation of attention, and (3) whether individuals differ reliably in their strategies for processing frequentistic data. The "realistic" task scenario (primary task) was one of evaluating hypothetical college applicants whose credentials included the usual array of personal and academic data. The frequentistic events were applicants of a particular, easily recognized, and culturally salient type (e.g., women; minority groups). "Prior expectations" were created by reinforcing the actual base rates (which were well known to most of the subjects) with additional instruction and/or consistent preconditioning data. Subsequent evidence was discrepant (usually by 15-20%) from this prior rate. While the findings did not answer all three questions conclusively, they suggested that: (1) prior expectations do play a significant role in subsequent estimates

of observed event frequencies; (2) the effect can be ameliorated by task conditions or instructions designed to shift attention to the evidence, but much less easily than might be expected; and (3) the tendency to process (or depth of processing) frequentistic evidence is subject to a strong individual difference component. All these findings are consistent with an attention-control account of intuitive frequency records.

Intuitive Frequency Judgments as a Function Of Prior Expectations, Observed Evidence, and Individual Processing Strategies

It is commonly assumed that future expectations have some basis in past experience, particularly in the case of repetitive or "frequentistic" events. What this implies is that an observer somehow "tags" and records the serial property of like occurrences, and when called upon to make judgments or decisions involving their future likelihood, draws upon the stored records.

Basic though they may seem, the cognitive processes underlying the formation and use of intuitive frequency records are neither simple nor well understood. One reason is that the study of intuitive frequency poses some unique methodological problems: the experimental task, for example, is always a secondary one; the paradigm, one of incidental learning. Another reason is that while it is germaine to a variety of research areas (e.g. verbal learning, behavioral decision theory, opinion revision), intuitive frequency is rarely of central interest.

What information has appeared on this topic has been reviewed several times in recent years (Howell, 1973; Hintzman, 1976). The consensus seems to be that each event repetition is at first encoded uniquely in memory according to the context in which it has appeared. The initial representation of frequency is thus a literal one consisting of "multiple copies" of the event which are produced fairly automatically as a by-

product of the encoding process.

The view that frequency encoding is an "automatic" process stems largely from the general finding that pre-experimental instruction (or subject cueing) has little if any effect on the accuracy of subsequent FEs (Flexer & Bower, 1975; Howell, 1973). However, the highly artificial stimuli used in traditional laboratory investigations of FE draw the generality of this finding into question. The typical stimuli such as CVC strings or random word lists are totally lacking in the richness or multidimensionality that characterizes most frequentistic events in the "real world." Underwood (1969) points out that frequency is but one of several distinct attributes that can serve to distinguish one event from another in memory. The frequency attribute may be exceptionally salient in the FE paradigm due to the simplicity of the stimuli and demand characteristics of the experimental task. For other real world events, the frequency attribute may not be so salient. For example, Lichtenstein, Slovic, Fischhoff, Layman, and Combs (1978) found that a number of biases and judgmental heuristics tend to underly subjects' inaccurate frequency estimates of lethal events. This suggests that people do not simply "tag" and "count" like occurrences as might be expected on the basis of laboratory investigations. Rather, the encoding and processing of frequentistic information appears to be, to some extent, under attentional control.

In the real world, event repetitions are rarely, if ever, viewed in a cognitive vacuum. The observer sees each occurrence against

a background of beliefs regarding its causation, history, and meaning. Moreover, he is unlikely to perceive frequency as the most salient characteristic of the task or circumstance at hand. If, then, special "active" processing is required to transform transient "multiple impressions" into a more lasting frequency record, it is important to learn what features of the person, situation, or task dictate whether the extra processing will, in fact, occur.

The experimental evidence regarding the importance of prior knowledge is as mixed as its theoretical interpretation. One conceptualization is that current observations are simply incorporated into an aggregate opinion in a serial fashion. Thus "prior hypotheses" are strengthened or revised gradually and iteratively in accordance with accumulating data. This implies no distinction between the weight accorded prior and current information. By contrast, Whitlow and Estes (1979) have proposed that historical evidence is subject to an obsolescence function such that frequency estimation reflects primarily current or recent observations. Both positions are supported by laboratory data using tasks which undoubtedly contribute to the desired emphasis. The point is, instances can be found in which observers rely upon prior knowledge almost to the exclusion of event occurrences; and others can be found in which they rely almost exclusively upon observed frequencies.

The present research derives from a somewhat different premise: the notion, introduced previously, that specific processing is required to transform "multiple impressions" into a more lasting frequency record.

If this is so, the role of prior knowledge could be to control how much attentive effort the individual invests in the transformation. Put simply, a strong prior belief could lead the observer to pay virtually no attention to his "multiple impressions," while a weak one could prompt him to process them intensively. In this view, quality of frequency judgment would reflect the interplay between prior beliefs and demand characteristics of the task. For example, erroneous prior beliefs would be expected to discourage the processing of observed events which could alter those beliefs, and hence would produce poor frequency estimates. However, if the task were somehow to signal a change in the generator of those events, that could offset the initial bias, encourage event processing, and improve the obtained frequency estimate.

The four experiments reported here were designed to explore various implications of the attention-control hypotheses for frequency judgment in a realistic setting. Realism, in this case, refers principally to the complexity and believeability of the primary task, and to the secondary or incidental nature of frequency estimation. Given a situation in which repetitive events are easily defined and naturally encoded at some level (but not necessarily as frequencies), the issue was whether prior beliefs and demand characteristics of the task control the formation of a frequency record.

The first question of interest was simply whether frequency estimation is affected by prior beliefs and, if so, in what fashion. The

second was how the task might operate to control level of attention accorded the frequency characteristic. And the third, which arose as a result of attempts to answer the first two, was whether people differ systematically in their inclination to process frequentistic evidence. In all four studies the situation was constructed such that prior beliefs were at variance with the observed evidence (actual event frequencies). Inferences as to the role of particular variables in the processing of frequentistic evidence were drawn on the basis of how closely the estimates corresponded to prior vs. observed frequency information.

Experiment 1

This study was designed to test the assumption that prior beliefs about generaters of frequentistic events influence the allocation of attentive effort in a FE task.

A primary task was developed in which evaluators (subjects) were required to study and rate the admissions credentials of a large number of hypothetical college applicants. The secondary or incidental frequency information was thus carried by the distinguishing characteristics of the applicants (e.g. race, sex, etc.). The basic approach consisted of a preconditioning session, during which subjects observed a sample of 80 profiles that were strictly representative of the Rice applicant pool, and an experimental session, during which they saw an altered sample. Alteration was in terms of the proportion of minority-group and female applicants; subject groups differed in the number of applications they

saw at the altered level and in the magnitude of the alteration. The primary issue of concern was whether FE's obtained in the experimental session (Session 2) would indicate some accomodation toward the "new" evidence or whether subjects would be predisposed to respond as they had in the conditioning phase (Session 1), indicating a lack of sensitivity to changes in frequentistic data and/or a strong reliance on prior beliefs.

Method

Subjects. One hundred and twenty undergraduates from introductory and intermediate level psychology courses volunteered for the present study. In exchange for their participation, all subjects received bonus points toward their final course grades.

Materials and procedures - Session 1. Subjects were instructed to function as undergraduate admissions committee members in deciding on the acceptability of 60 hypothetical applicants. The applicants differed in terms of sex, race, and standing on standard admissions criteria such as teacher and counselor recommendations, rank in graduating class, National Merit Qualifying Test, and the Scholastic Aptitude Test. The profiles were representative of the actual Rice applicant population. Basically, subjects were required to study the information contained in the profiles and to assign each applicant a rating on a 7 point scale ranging from "outstanding" to "reject." As the "primary task," this rating procedure insured that some attention was paid to all the pertinent characteristics of each event (applicant). Accurate repre-

sentation of the various attributes was designed to reinforce the subjects' prior beliefs regarding the nature of the applicant pool. Following the evaluation task, subjects responded to a brief questionnaire "proportedly" developed to assess attitudes and perceptions of the undergraduate admissions process. Embedded within the questionnaire were items designed actually to measure their beliefs about the frequencies of females and minority group members in the applicant pool. These estimates provided a baseline for assessing the impact of the subsequent manipulations.

Materials and procedures - Session 2. In the second, or experimental session subjects reviewed either 20, 40, 60 or 80 additional applicant profiles for which the frequencies of female and non-caucasian applicants were either (a) identical to their prior beliefs, as assessed in Session 1, (b) 10% greater than previously believed, or (c) 20% greater. The resulting experimental design consisted of the factorial combination of 4 levels of applicant sample size and 3 levels of frequency shift with 10 subjects per cell. Estimated frequencies (in percent) of females and minority group members contained in the Session 2 sample served as the dependent measures. It should be emphasized that the experimental materials were fully individualized in Session 2. That is, each subject reviewed a unique applicant pool which had been generated in accordance with distributional estimates obtained in Session 1, and then manipulated on the basis of cell assignment.

Results and Discussion

Session 1 data were analyzed for subject agreement on the two frequency estimates of interest. Because standard deviations were lower for the estimates of females in the observed samples (9.11% vs. 10.76% for minorities) the female estimate was considered the more appropriate index for the study of experimental effects.

The influence of shifts in the evidence on estimates produced by the various groups is shown in Figure 1, a plot of error scores.[1]

Figure 1 about here

Had subjects processed the observed evidence *and used it exclusively* in their frequency estimates, error in the amount of the "no-shift" conditions (roughly 19%) would have been expected under all conditions. On the other hand, had they relied entirely upon their prior beliefs, error would have been expected to increase in direct proportion to the amount of the shift (10% and 20%). Had they altered their prior opinion gradually as inconsistent evidence accumulated, a trend over number of observations would have been expected in which large initial error would converge on the "no-shift" level.

First, no reliable convergence developed, although a tendency in that direction does seem possible in the 10% condition. The analysis of variance indicated that neither the number of observations, $F(3,108) = .60$, $p = .613$, nor its interaction with shift, $F(6,108) = 1.81$, $p = .100$, approached significance. Secondly, error did increase significantly as

a function of shift magnitude, $F(2,108) = 6.42$, $p = .002$, although it is clear from Figure 1 that the mean differences did not generally approach the magnitude expected if the evidence were totally ignored. And finally, the amount of unsystematic variance obtained both between and within groups makes further speculation on the underlying cognitive processes unwise. In short, the findings suggest that event (or rather event-characteristic) frequency information is processed to a degree even in this very demanding, very complex decision scenario; however, prior beliefs also play a substantial role, and the manner in which the two are integrated is not clearly evident.

Experiment 2

As a completely between-subjects design, the first study avoided any possibility that attention might be cued to the secondary task by repeated frequency estimations. Such a design, however, does not permit the tracking of individual estimation functions as evidence is accumulated. By contrast, a within-subjects design permits a closer inspection of the estimation shift, but raises the possibility of unwanted cueing (Slovic & Lichtenstein, 1971). For this reason, Experiment 2 was designed as a within-subject study of frequency shifts, but cueing or attention-manipulation was included as a second (between subjects) variable. The object here was to determine whether individual FE functions reflected the shift in evidence frequencies, and if so, whether the change was abrupt or gradual. Further, if cueing were an important factor, those conditions with the more explicit instructions

would be expected to produce the most consistent shift functions.

Method

Subjects. Forty undergraduates from upper level psychology courses volunteered to participate in exchange for bonus points toward their course grades.

Materials and procedure. The primary task was the same as in Experiment 1: subjects served as admissions committee members who rated a large number of hypothetical college applicants. In contrast to Experiment 1, subjects made four frequency estimates, one after each block of 20 observations. To justify the repeated estimates, instructions specified that the blocks represented applicants from four different geographical areas within the United States. Of course, several distractor questions were also presented in each set to preserve the "face-validity" of the cover story.

Subjects were seated in a cubicle and presented with a set of written instructions. In addition to the primary task information, these instructions either did or did not provide additional information of two kinds: an explicit secondary task (FE) description, and prior data on the population characteristics. Thus four groups were formed on the basis of the presence or absence of the additional information. In cases where explicit task information was provided, subjects were told that they might be required to recall, among other things, the proportions of female and minority group applicants contained in the four evidence blocks. Specific generator information consisted of a

detailed description of admissions statistics compiled over a 10-year period. It was hoped that these statistics would lead to the formation of or reinforce existing strong beliefs about the applicant population. After reading the instructions, the subjects worked through the profiles (displayed on a CRT) at their own pace.

The experimental design consisted of a 2 (secondary task info, no secondary task info) x 2 (generator info, no generator info) x 4 (frequency estimates) model with repeated measurements on the last factor.

Results and Discussion

When generator information was supplied, subjects were told that ordinarily 25% of the Rice applicant population was non-caucasian. Yet each of the four evidence blocks actually contained 45% non-caucasian applicants, a shift of 20% above the stated value. The frequency estimates obtained from those who had been exposed to the generator information did not differ in any substantive way from those who had not received the information, $F(1,36) = .31$, $p = .578$. There are at least two plausible explanations for this finding. First, the majority of subjects who received generator information simply may not had attended to it and therefore their responses reflected only the evidence or some prior beliefs about the applicant population. Second, the impact of the generator information manipulation may have been diffused because the information was already "common knowledge." That is, some may have entered the study with strong beliefs about the proportion of minorities in the applicant population. This interpretation is supported by the

finding reported previously that 120 undergraduates believed, on the average, that 24.75% of applicants were non-caucasian (S = 10.77), an estimate quite close to the population value of 25%. Due to the possible diffusion of the generator manipulation, the attention-control function of prior beliefs remains unclear.

Secondary task information also failed to influence obtained responses reliably: mean frequency estimates (in percent) for the cued and non-cued conditions were 37.22 and 38.49 when collapsed across the four evidence blocks. This difference was not statistically significant, $F(1,36) = 0.12$, $p = .730$.

Post-experimental interviews revealed that subjects had no doubts about the intent of the study; they believed that they were involved in the investigation of undergraduate attitudes and perceptions of the admissions process--and that was all. Furthermore, no one suspected that there was interest in their abilities to recall the frequencies of particular profile dimensions. This was not expected in view of the fact that 20 subjects had been given specific instructions informing them that they would be called upon to make frequency judgments. Apparently, task cueing had nominal, if any, impact on subjects and therefore any inferences concerning its effects on frequentistic processing strategies should be guarded. This finding does suggest, however, that the use of the within-Ss design is totally appropriate for the present study. As one would expect on the basis of findings already discussed, the Task Info X Generator Information interaction did not account for an appreciable

amount of variance in FEs, $F(1,36) = 0.64$, $p = .428$.

Analyses of individual response profiles indicated a tendency for subjects to adjust FEs toward the evidence with greater exposure to it. Collapsed across between-subject conditions, the mean frequency estimates (in percent) for evidence blocks 1 though 4 were 36.48, 36.08, 39.26 and 39.65 respectively. These means differed significantly, $F(3,108) = 3.10$, $p = .030$. The significance of this difference was due largely to a single component of the test: the comparison of frequency estimates from blocks 1 and 2 with blocks 3 and 4. The test of this individual component documented the discontinuous shift toward the evidence that occurred between evidence blocks 2 and 3, $F(1,108) = 9.14$, $p = .003$. While these findings are striking, they are unrelated to the between-subject manipulations employed in the study. However, the fact that there were no between-group differences in patterns of frequency estimates should not be taken as an indication of large-scale agreement, and adherence to the evidence. On the contrary, there was variability in both the accuracy and patterning of frequency responses.

Cluster analysis was used to identify different processing strategies that were unrelated to the a priori groupings defined by the presence or absence of task and generator information. A standard clustering routine described by Johnson (1967) was used to compute a standardized distance matrix for the 40 response profiles obtained in the study. Cluster memberships were determined on the basis of inter-vector distances in Euclideon space. A hierarchical inclusion model was used in the present

study that involved the systematic reduction of N (where N = the number of Ss) response vectors to a single response vector that best represented the data. The reduction entailed N-1 stages, where at each stage the two vectors exhibiting the greatest homogeneity were combined. The reduction process was terminated at a pre-determined point of compromise between theoretical parsimony (i.e. number of clusters extracted) and empirical distinctiveness of the clusters. Clusters derived from these procedures are depicted by functions (a) and (c) in Figure 2. Function (b) indicates the responses that would be expected from individuals maintaining perfect frequency records based on the evidence, whereas function (d) represents the responses expected of those relying solely on generator information.

Insert Figure 2 about here

Inspection of Figure 2 reveals several differences between the response profiles of clusters 1 and 2. The most obvious differences are seen in the FEs based on the first two evidence blocks; members of cluster 1 seemed to attend to the evidence (a trend that continued throughout the task) while the cluster 2 membership provided estimates more in line with what would be expected of those relying exclusively on prior information. The response profile for cluster 2 is characterized by a marked shift toward the evidence between blocks 2 and 3. Moreover, the shift appears discontinuous as would be expected if a shift in <u>attention</u> were involved.

Insert Table 1 about here

The composition of the cluster memberships is given in Table 1. As expected on the basis of the ANOVA discussed earlier, the memberships of both clusters are evenly distributed among the four Task/Generator conditions. This implies the presence of individual differences in frequentistic processing strategies that are not necessarily controlled by task demands or prior generator beliefs. However, it should be reiterated that the study did not produce solid conclusions regarding the impact of task cueing and generator information on processing strategies. Unfortunately, it is not clear whether those who received generator information actually processed it, did not believe it, or "knew it anyway." Similarly, responses on the post-experimental questionnaire indicated a lack of cognizance of, or serious attention to, the explicit task information provided. Apparently, subjects found the task scenario so credible and inherently interesting that the peripheral aspects of the study (i.e. from the Ss' perspective) such as the Task/Generator manipulations simply were not regarded as important. This, of course, is a positive gesture from the standpoint of task realism. The studies described in the pages that follow were conducted to obtain a clearer view of the FE revision process as well to obtain an unobscured assessment of the effects of task cueing (i.e. direction of attentive effort).

Experiment 3

In the studies described thus far, subjects were either exposed to

a representative prior sample of college applicants in one session and shifted to an altered sample in another session, or they were given prior information verbally followed immediately by a non-representative sample. In neither case were they allowed to experience the frequency shift directly in the course of a single experimental session. It is possible that the perceived contrast between prior and experimental frequencies is not as pronounced under delayed conditions. Therefore, the present experiment was designed to incorporate the shift within a single session and thereby eliminate the delay. In a larger sense, the purpose of the study was to determine whether, under optimal conditions, subjects process the frequency attribute of realistically complex events in the course of performing the primary task. A negative outcome would suggest that subjects are not inclined to record specific event frequencies in such tasks.

Method

Subjects. Twenty undergraduates from introductory psychology courses volunteered to participate in this experiment and were paid $2.50.

Materials and procedures. As in the previous study, subjects were told that they would be evaluating applicants from different geographical regions within the United States and were then presented with an 80-item conditioning sample composed of 40 males and 40 females. Individual beliefs regarding the proportion of females were measured, but the main thrust of the conditioning trials was to generate realistic prior beliefs (50% female). In fact, the conditioning task was structured

explicitly to emphasize the sex characteristics.

Subjects were given 160 3" x 5" index cards representing the applicant population under study and were instructed to sort the first 80 (i.e. conditioning sample) into four piles; (1) accepted males, (2) rejected males, (3) accepted females, and (4) rejected females. Subjects were aided in their initial FEs by the fact that the true proportion of females in the conditioning sample could be deduced simply by observing the relative heights of the four card stacks that resulted from the sorting procedure. That is, subjects could see that collapsing across accept/reject categories would yield two card piles (male/female) that were of equal height. This procedure was used to instill a relatively concrete representation of pre-shift generator characteristics. After the individual pre-shift beliefs were measured, subjects were instructed to sort the remaining 80 cards into accept and reject piles only, thereby eliminating an important cue in determining the proportion of females in subsequent evidence blocks. The remaining 80 profiles were evaluated in four blocks of 20 observations each as in previous studies. Thirty percent of the applicants in each block were female; a 20% shift from the conditioning sample. After each of the post-shift blocks, subjects were required to make the same FEs as they did after observing the pre-shift evidence. Cumulative graphs were maintained for each subject's estimates so that he or she could observe previous estimates at any time and could monitor the development of the individualized profile.

Results and Discussion

As expected, the concrete representation of pre-shift generator characteristics led to generally accurate beliefs regarding the proportion of females in the applicant population. A mean pre-shift estimate of 48.25% was obtained. This compares with the generated frequency of 50%. A standard deviation of 4.94 indicated close agreement on these estimates. Success in establishing the desired prior belief made the 20% shift in the experimental sample a meaningful one. Of course it was also possible to observe the course of individual profiles on pre- and post-shift estimates.

Because this investigation did not involve between-subject measures, the data seemed especially well suited for the profile categorization or clustering procedure described in Experiment 2. Recall that the procedure combines response vectors on the basis of inter-vector distances in Euclidean space. Using essentially the same inclusion criteria as in the previous experiment, two systems were identified as best representing the response profiles of the 20 subjects. The two systems are plotted as functions (a) and (c) in Figure 3. Function (b) reflects the evidence, or the actual proportions of females contained in each of the evidence blocks. Using function (b) as a reference, it is

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Insert Figure 3 about here

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clear that the 11 members of system 2 processed the evidence throughout the task.[2] It is interesting to note that roughly 25% of the subjects

in Experiment 2 also appeared to perceive the frequency shift immediately and continue to track the evidence throughout the task. The nine members comprising system 1 demonstrate a markedly different response pattern. While both systems reflect the frequency shift between blocks 1 and 2, only system 2 appears to sustain evidence processing. After the second evidence block, system 1 estimates shift discontinuously <u>away</u> from the evidence (toward pre-shift levels) and then settle back to the approximate midpoint between prior beliefs and the evidence. One may be inclined to challenge the representativeness of system 1 because of its counter-intuitive nature and lack of consonance with any model of systematic opinion revision. Yet inspection of the individual response profiles comprising the system shows it to be highly representative. In fact, there was close agreement among subjects within the system 1 as evidenced by standard deviations of 2.20, 8.46, 4.64, 5.59 and 6.61 for the respective evidence blocks. This compares with standard deviations of 5.39, 7.57, 7.69, 6.11 and 9.39 for system 2 estimates. One possible explanation for the unusual shape of function (a) is that for members of system 1 the intuitive frequency record is not maintained and updated automatically; rather frequency processing is activated by perceived frequentistic shifts occurring between contiguous evidence blocks. In the absence of such shifts, these individuals may maintain (or revert to) their prior generator beliefs. One implication of this view is that individuals who use this strategy would be largely unreceptive to low magnitude frequency shifts, or a progressive series of gradual shifts. Clearly, before pursuing this line of speculation much further,

it will be necessary to replicate (perhaps in other contexts) the response patterns described above and perform more precise analyses of the cognitive processes underlying individual differences in responsivity to frequentistic data.

In general, then, the results of Experiment 3 support the viability of the present task scenario for studying realistic frequency processing. They show that under optimal presentation conditions people can and do encode incidental frequency evidence for salient characteristics of complex events even when clearly engrossed in the primary task. Moreover, when they react to a frequency shift, subjects do so abruptly rather than gradually, a finding that is more consistent with an attention-control model than with an evidence-aggregation model. It suggests that when prompted to attend to (or process more deeply) the salient features of repeated events, people are prone to discount or abandon their prior beliefs rather than adjust them systematically as the new evidence is acquired. The findings also support the earlier conclusion that people differ in their inclination to process (or persist in processing) frequentistic evidence.

Experiment 4

The final experiment in this series was conducted to clarify the relationship between pre-experimental task cueing and individual frequency processing strategies. Recall that in Experiment 2 there was little evidence to suggest that prior cueing influences strategies in any substantive way. However, it was suspected that the manipulation was

either too subtle or that the attention control exerted by the primary task was too complete to allow any variation in "incidental" frequency coding. Therefore, the general task scenario was modified in Experiment 4 to insure the diversion of some attentive effort to the secondary (frequency estimation) aspects of the task. Having shown in Experiment 3 that ongoing task features can contribute to the processing of frequency evidence, the question here was whether prior cueing can have the same effect. This should be the case if the chief cognitive element is attention.

Method

Subjects. Twenty four undergraduates from introductory and intermediate level psychology courses volunteered to participate in the present study. Each received $2.50 for his/her participation.

Materials and procedures. Subjects were presented with the standard primary-task instructions plus a brief script that detailed some of the "controversies" inherent in undergraduate admissions decisions. Basically, they were told that applicant sex and race were attributes that received considerable attention for reasons of quotas, affirmative action programs, and so forth. It was suggested that in order to be an "effective and influential committee member one must possess a command of the admissions data," particularly those data pertaining to the relative proportions of females and Blacks rejected. These instructions were reinforced by a subsequent statement explicitly requiring subjects to attend to the race and sex of applicants they chose to reject, and by the warning that

their performance as admissions committee members would be assessed on the basis of (a) their <u>consistency</u> in rating, and (b) their ability to recall the race and sex of the applicants they chose to reject. This evaluative element was introjected to further encourage allocation of some attention to the secondary (frequency) task. Thus after being cued on the necessity to encode frequency information for the rejected group, the subjects sorted the 80 applicant profile into piles labeled <u>accept</u> and <u>reject</u>.

Following the completion of the task, two <u>cued</u> FEs were obtained by querying subjects on the absolute numbersof females and Blacks that were rejected. What the subjects did not know was that they would be called upon to make the same FEs for the group they chose to accept, a <u>non-cued</u> sample. The design, therefore, consisted of a simple within-subjects comparison of two cueing conditions and two cued variables (sex vs. race).

Results and Discussion

Subjects sorted the applicant profiles according to their individual rating policies; therefore, the actual composition of the accept and reject piles varied across subjects. An initial step in this analysis was to tabulate the frequencies of females and Blacks actually contained in the piles, and then to compare these values with the estimates provided. The discrepancies between estimates and tabulated values were coded in terms of percent deviation. Four deviation scores were derived for each subject (cued vs. non-cued estimate x sex vs. race variable).

As expected, there was no reliable difference between the FEs of females and Blacks after collapsing across cueing conditions, $F(1,22) = 1.07$, $p = .312$. But there was a substantial difference in the accuracy of FEs for cued and non-cued samples. The mean deviation (in percent) between tabulated and estimated values was 39.87 for the cued sample compared with a mean of 73.73 for the non-cued sample. The difference associated with task cueing was highly significant, $F(1,22) = 9.00$, $p = .007$. This finding offers strong support for the view that demand characteristics of the task can direct attentive effort to the processing of the frequency attribute of an event.

General Discussion

One of the central questions in the present series of experiments concerned the role of prior beliefs or expectations in the determination of how much attentive effort a subject invests in processing frequentistic data. The present findings suggest that prior beliefs about frequency generators play a major part in the allocation of attentional resources; particularly in the absence of task-related cues indicating a "need" to process frequency data more deeply. Subjects in Experiment 1 were not particularly responsive to 10% or even 20% shifts in the frequency of female applicants although, at 20%, they appeared to process some of the discrepant evidence. The insensitivity of subjects to frequency shifts, regardless of the number of observations made, casts doubt on the generality of previous findings (e.g. Hashier & Chromiak, 1977; Howell, 1973) suggesting that frequency information is encoded automatically.

As suggested earlier, the discrepancy between the present and previous findings may be due to differences in task complexity. The frequency attribute or "tag" was one of several attributes comprising the complex and realistic stimuli used in the present study. As predicted, the determination of whether or not the frequency attribute is processed appears to be under attentional control. In Experiment 1, the secondary task was minimally cued--subjects had no reason to suspect that frequency was a relevant attribute of the events they observed. Consequently, the "tag" or frequency representation was not encoded and subsequent FEs reflected the retrieval of information on similar events or explanatory "heuristics" stored previously (i.e. "prior beliefs").

Demand characteristics of the task do, however, seem to influence the allocation of attentive effort in the processing of the frequency attribute. Subjects in Experiment 1 provided a single FE which, for the most part, reflected their own prior beliefs. However, in Experiment 2, a majority exhibited a discontinuous shift toward the evidence after reviewing three evidence blocks. Initially, subjects in Experiment 2 were faced with the same incidental learning task as those in the preceeding study. Yet upon making a second FE, a proposition of the form "I have been asked to make FEs twice so far ... frequency must be important!" may have been deduced.[3,4] Propositions about which aspects of a task are most critical probably operate to regulate attentive-effort. In Experiment 2, the correct proposition could not have been deduced before the onset of the third evidence block. The improvement

of FE performance that occurred after block 3 provided evidence that frequency processing had been initiated, perhaps in direct response to a deduction regarding the "true purpose" of the study.

One obvious interpretation of the findings reviewed thus far is that demand characteristics influence task performance by way of the formation of subjectively-based propositions regarding the nature and purpose of the experimental task. In turn, these propositions lead to the allocation or distribution of attentional resources in such a way as to maximize overall task performance. This view clearly implies the presence of a "utility" factor involved in attention allocation. Navon and Gopher (1979) have argued that utility is a powerful determinant in cognitive resource allocation. The basic idea is that people determine what the performance criteria are for a particular task and then allocate resources such that the most important aspect of a task receives the greatest amount of attentive-effort.

In Experiment 4, the utility for processing frequency attributes was manipulated directly through the encouragement of subjects to monitor the frequency with which females and Blacks were rejected. The utility of frequency processing was further enhanced by the "threat" of evaluation. Subjects were informed that their performance as admissions committee members would be assessed on the basis of their abilities to recall the cued data. As expected, FE performance was substantially better for these cued data (i.e. number of females and Blacks rejected). This finding offers support for the assumptions

(a) that demand characteristics operate to direct attentive effort, and (b) that frequency attributes are not processed automatically, but rather selectively on the basis of perceived utility.

The final question of major importance to the present series of studies concerns the existence of individual strategies for processing frequentistic data. The hierarchical clustering performed on data from Experiments 2 and 3 revealed three distinct response patterns: (1) an immediate and sustained shift toward the new evidence, (2) a strong resistance to new evidence in favor of prior beliefs and (3) a discontinuous shift toward evidence only after extensive exposure to it.

These differences can also be explained within the context of an attention-control representation of frequency processing. Recall that the stimuli used in each of the four experiments were multidimensional and that the primary task (i.e. one of applicant evaluation) was fairly demanding. Clearly the general task scenario consumed a substantial amount of attentive capacity. If one assumes that there are individual differences in the amount of attentive capacity available, then it is reasonable to assume that there is variability in the reserve attentive capacity available for the secondary task (i.e. FE). The disparity in secondary capacities alone could account for individual differences in processing strategy. Differential or idiosyncratic interpretations of demand characteristics together with variable (subjectively-based) utilities associated with task performance may have accounted for still more individual variation in processing strategy.

Conclusion

Frequency estimation is undoubtedly a highly important cognitive capability. It underlies critical decision making activities such as choice, probability estimation/and prediction. Moreover, it forms the core of the expectancy which, in turn, is central to broader constructs such as motivation and satisfaction. A more complete understanding of all these areas will come a step closer with the development and refinement of adequate models of frequency estimation. The attention-control account of frequency presented here seems to be a promising framework for future research, particularly in view of its apparent power to explain both task- and subject-related differences in frequency estimation.

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Footnotes

1. Points representing cells in common shift conditions are joined to illustrate certain trends.
2. The final FE in System 2 appears to indicate a substantial departure from the evidence. However, the magnitude of the departure is due largely to the presence of an extreme value. One subject, for whatever reason, believed that only 2% of the final evidence block was female, an estimate 2.23 standard deviations beyond the mean.
3. This adheres closely to the logic of the propositional encoding theory of frequency representation as delineated by Anderson and Bower (1974).
4. Recall that in post-experimental interviews, subjects did not <u>report</u> an awareness of the importance placed on FEs. Yet, this finding does not preclude the possibility that they had generated hypotheses concerning the nature of the task which, in turn, affected the allocation of attentive effort.

Table 1

Composition of Cluster Memberships

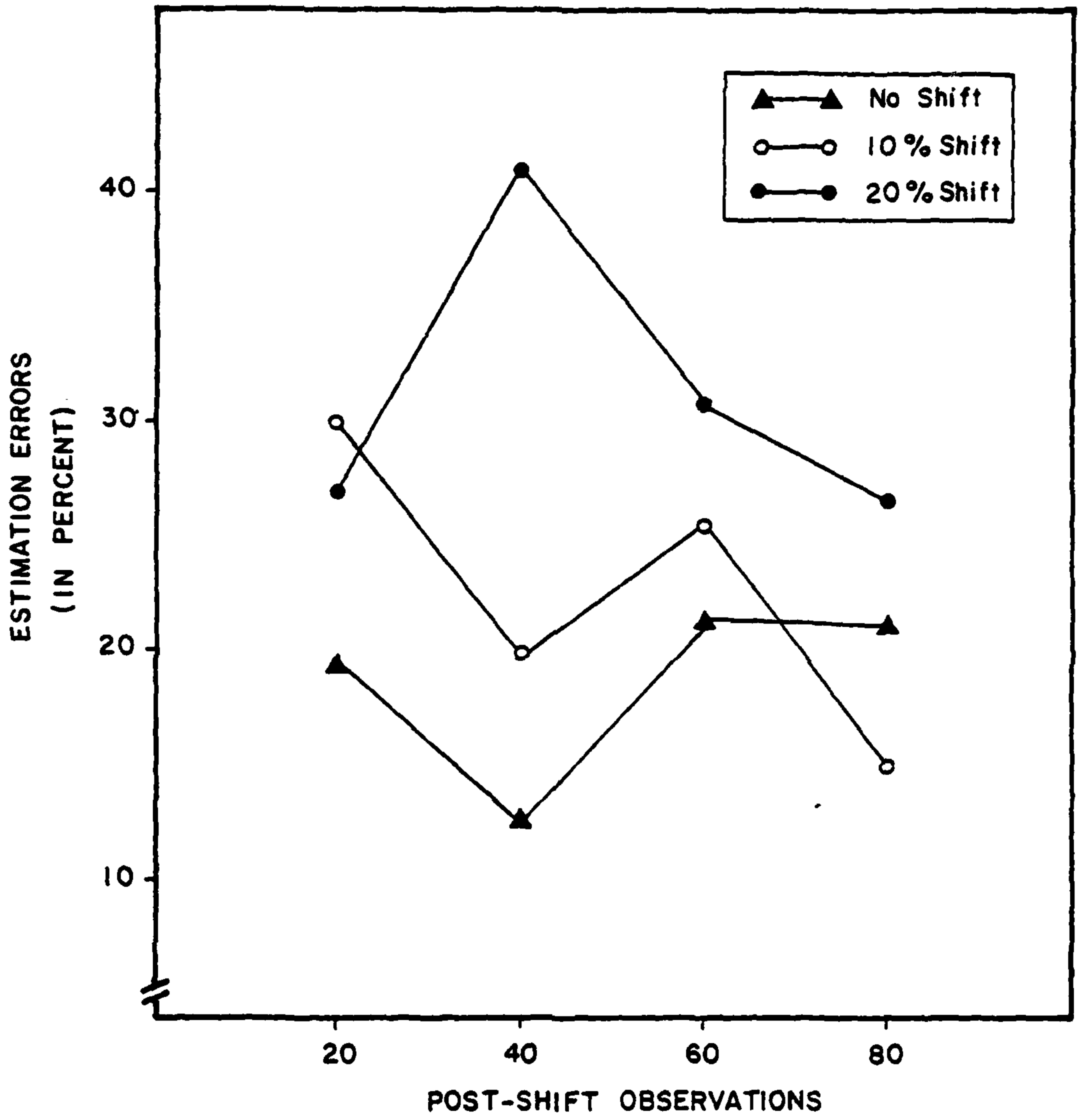
Condition		Cluster 1	Cluster 2
Generator Info.	Task Info.	2	8
	No Task Info.	2	8
No Generator Info.	Task Info.	4	6
	No Task Info.	3	7
	Total	11	29

Figure Captions

Figure 1. Accuracy of frequency estimates as a function of shift magnitude and number of post-shift observations.

Figure 2. Response profiles obtained from hierarchical clustering procedures with profiles which would be expected from strict adherence to the evidence or prior generator information.

Figure 3. Profiles consisting of pre- and post-shift responses obtained from hierarchical clustering procedures in relation to a plot representing the evidence as presented to the subjects.



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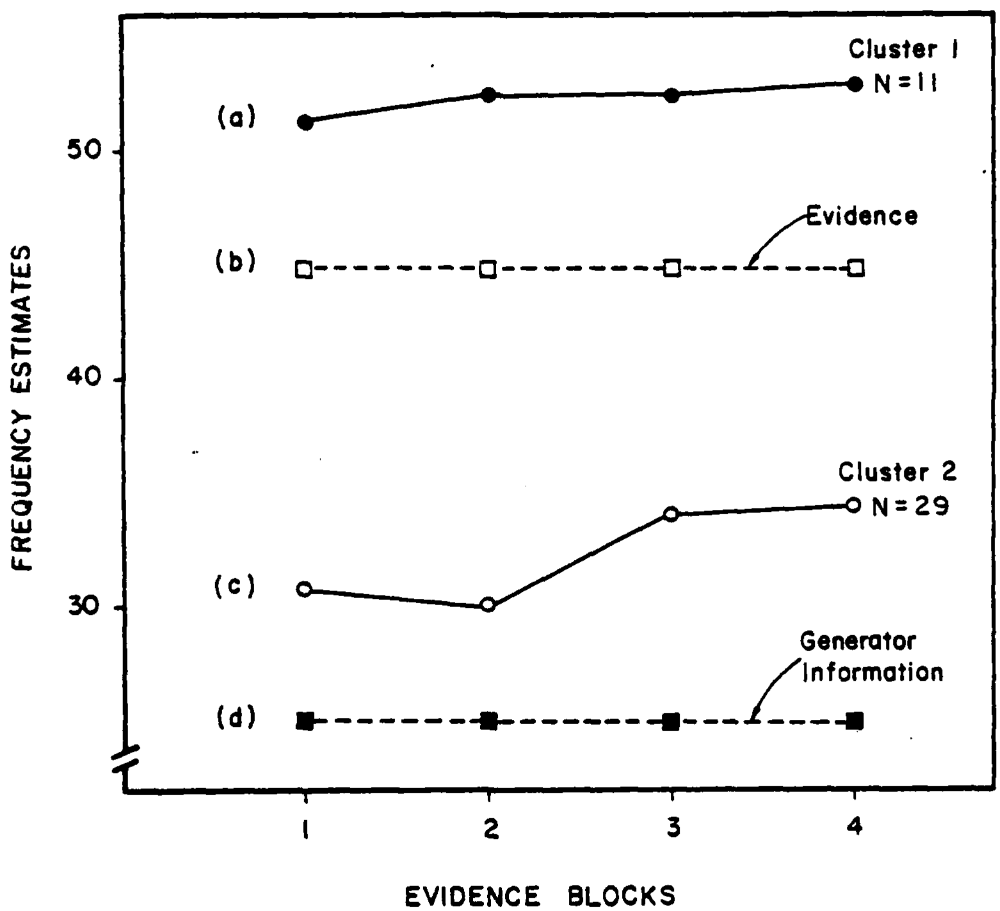

Figure 2. Response profiles obtained from hierarchical clustering procedures with profiles which would be expected from strict adherence to the evidence or prior generator information.

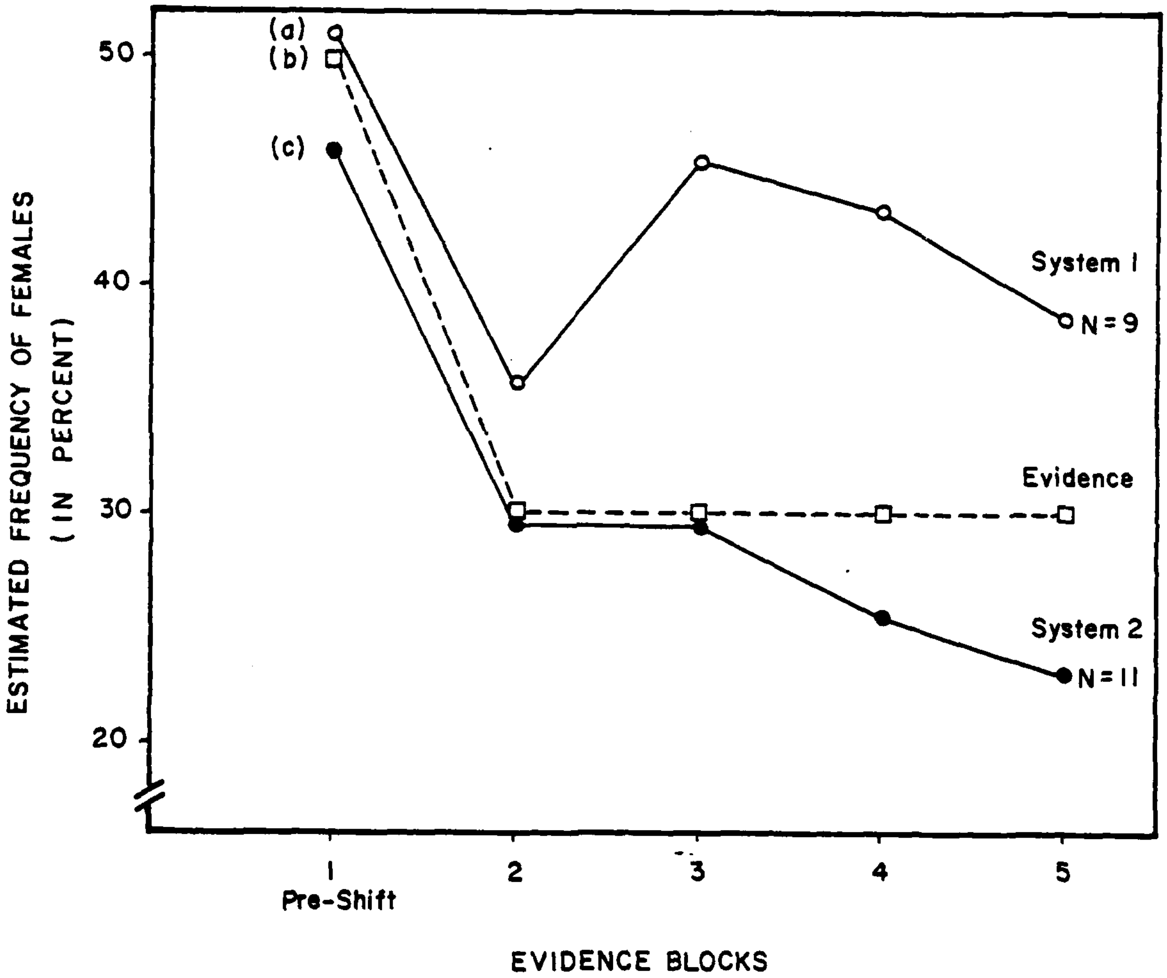

Figure 3. Profiles consisting of pre- and post-shift responses obtained from hierarchical clustering procedures in relation to a plot representing the evidence as presented to the subjects.

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